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# Review of renewable energy investment and financing in China: Status, mode, issues and countermeasures

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A B S T R A C T

With the support of national policies, China's renewable energy generation industry has experienced a rapid development period and entered the world forefront level, especially in the aspects of installed capacity and speed of newly installed capacity. However, with the rapid development of renewable energy, the power generation industry is facing more and more challenges, particularly in investment and financing. As for wind power industry, there are also some problems such as single financing channels, blindness of projects investment and so on, which will result in financing difficulties for some advanced projects. In addition, the problems for the investment of photovoltaic (PV) power generation leads to vicious competition and a tumble in international market, thus the overcapacity of China's entire PV industry emerges. Generally speaking, the renewable energy industry is facing a seemingly contradictory predicament of funding deficiencies and blind investment, which is derived from the government-centered renewable energy investment and financing. This government-centered mode has promoted the development of renewable energy industry in the early stage, but it cannot be adapted to the requirements of sustainable development. In view of these, the problems of renewable energy investment and financing are deeply studied in this paper.

This paper proceeds as follows: Firstly, the overview of the development of China's renewable energy industry is briefly introduced. Secondly, the status quo of China's renewable energy investment and financing is explored in detail based on overview of the following five perspectives: investment situation; investment and financing bodies; investment and financing means; sources of funding and financing channels. Secondly, the patterns and characteristics of renewable energy financing are summarized and a comparative analysis of wind power and photovoltaic power generation financing means is carried out. Finally, renewable energy investment and financing issues are discussed and further feasible proposals are put forward. In all, this paper is of great significance in the sustainable and healthy development of China's renewable energy.



**Contents**



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## 1. Introduction

Nowadays, the utilization and development of renewable energy has become an important measure to safeguard energy security, strengthen environmental protection, and tackle climate change all over the world. With the rapid economic and social development, China's energy demand continues to grow during a particular long period of time. Besides, energy resources and environmental issues have become increasingly prominent in China's power sector. Therefore, developing and utilizing renewable energy have become an extremely important way for China to address the increasingly serious energy and environmental issues. During the “11th Five-Year” period, with the promotion of “Renewable Energy Law” and relevant policies, China's renewable energy has developed rapidly in particular wind and solar power [1]. Wind power development has entered an all-round development stage, as well as solar power generation. Various renewable energy technologies have made significant progress and industrial strength has improved significantly.

Energy policies of all countries were facing uncertainties caused by the turmoil in the global financial markets in 2011. Even in this context, the global renewable energy investment still reached 257 billion dollars with a year-on-year 17% of increase. China's renewable energy sector investment was 51 billion dollars, which accounts for 19.8% of the total global investment, which has led the world for 3 years consecutively [2]. From the perspective of installed capacity in 2011, China added 90 GW installed capacity of power generation, while renewable energy installed capacity accounted for 1/3 and non-hydro renewable energy installed capacity accounted for 1/5 [3]. The newly installed capacity of China's wind power has reached 17 GW and the installed capacity connected to grid has climbed to 45.05 GW and the cumulative lifting installed capacity reached 62.4 GW. The newly installed capacity of China's solar power reached 2.2 GW which accounted for about 7% of the global newly solar installed capacity and the cumulative amount was about 3 GW [4].

The manufacturing industry of renewable energy in China has also experienced a rapid development in the situation of large-scale investment, and China has established a relatively complete wind power and photovoltaic manufacturing industries. Wind power equipment manufacturing capability grew rapidly and made it possible to manufacture various types of technologies, units and major parts of 1.5 MW and above [5]. In 2011, four of the world's top 10 wind turbine manufacturers were from China. Following the great-leap-forward development of wind power in China, grid bottlenecks gradually emerges. Frequent accidents

**Table 1**
Accident statistics of wind turbines off-grid in year 2010–2011.

| Province | | 2010 | | | 2011 | | |
|---|---|---|---|---|---|---|---|
| | | Number of off-grid | Loss of output | | Number of off-grid | Loss of output | |
| | | | 100,000–500,000 kW | More than 500,000 kW | | 100,000–500,000 kW | More than 500,000 kW |
| Hebei | | 12 | 4 | | 128 | 36 | 8 |
| Inner Mongolia | Eastern Inner Mongolia | 11 | 2 | | 8 | | |
| | West Inner Mongolia | 6 | 6 | | 7 | 5 | |
| Liaoning | | 34 | 1 | | 19 | | |
| Jilin | | 4 | 1 | 1 | 4 | | |
| Fujian | | 3 | | | 5 | | |
| Hunan | | 1 | | | 2 | | |
| Hainan | | 9 | | | | 2 | 0 |
| Guangdong | | | | | | 6 | |
| Chongqing | | | | | 2 | | |
| Sichuan | | | | | 3 | | |
| Gansu | | | | | 15 | | |
| Total | | 80 | 14 | 1 | 193 | 54 | 12 |

caused by wind turbines quality frequently occur (shown in Table 1), as well as the surplus manufacturing capacity and blind expansion planning of wind power industry. Since 2011, China's wind power has entered an adjustment stage, with more attention to guide the rational and standardized development of this industry [6].

Since 2004, because of the present situation of European market, China's PV manufacturing has grown dramatically. China has become the world's largest producer of solar cells in 2007, whose exports accounted for more than 60% of the global market in 2011 [7]. According to the statistics from photovoltaic industry alliance of Ministry of Industry, the total capacity of more than 160 affiliated companies has reached 35 GW. European countries dramatically adjusted photovoltaic industrial policies in 2011, which has resulted in the reduction of subsidies for photovoltaic power generation [8]. The United States and Europe have launched the “anti-dumping, anti-subsidy” investigation in 2011, hindering the development of China's PV industry in the international market.

It is of great significance for China to develop domestic renewable energy manufacturing and promote the terminal applications. The reason is as follows: first, it is a significantly important opportunity for developing countries to catch up with developed countries in renewable energy production capacity; moreover, it is a strategic choice for major emission countries to improve the energy structure [9]. Thus, it is of significance to study China's renewable energy financing issues. How China, as a developing country, has achieved such a large scale investment in renewable energy? What are the major investment and financing channels? What is the investment composition of power generation projects? What kind of mechanism Chinese government took to promote the financing of wind power and photovoltaic power generation? What characteristics does China's renewable energy financing have? Is financing mechanism under current situation able to be adapted to the future application development of large-scale renewable energy? These issues will be deeply discussed in this paper.

The selected studying targets in this paper are relatively mature wind power and photovoltaic power generation. This paper proceeds as follows. First, an overview of the development of renewable energy industry in China is briefly introduced. Second, renewable energy investment and financing is analyzed from investment profile, developers, financing means, capital composition and financing channels. Third, this paper mainly focuses on means and effects of renewable energy financing. Forth, renewable energy investment and financing problems are analyzed and appropriate countermeasures are proposed. Finally, a conclusion is drawn.

## 2. Overview of renewable energy industry development

China is abundant in renewable energy and has experienced a fast development in recent years. During “11th Five-Year”, renewable energy has developed rapidly, with the increasing expansion of the development and utilization as well as the significant promotion of technologies and equipment, the renewable energy has become an important part of China's energy development. In 2011, China's installed capacity of power generation was 1060 GW, among those, thermal power, hydropower, nuclear power, wind power, solar power, and the remaining biomass, geothermal and ocean energy installed capacity occupied 72.2%, 21.7%, 1.2%, 4.3%, 0.2% and 0.4% respectively[10]. As shown in Fig. 1. The total generation capacity is 4740 TWh, in which thermal power, hydropower, nuclear power, wind power, solar power, and the remaining biomass, geothermal and ocean energy installed capacity

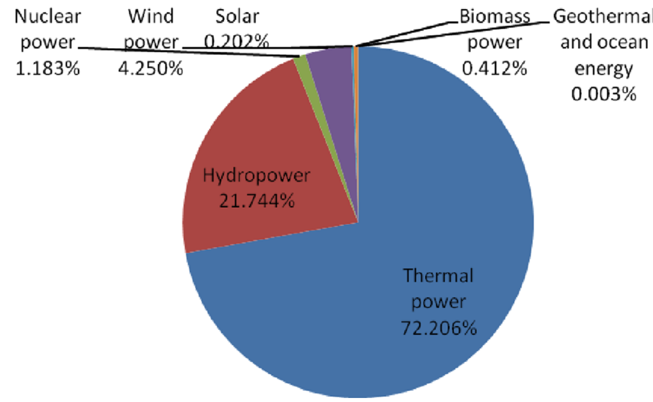



**Fig. 1.** Composition and proportion of China's power supply installed capacity in 2011.

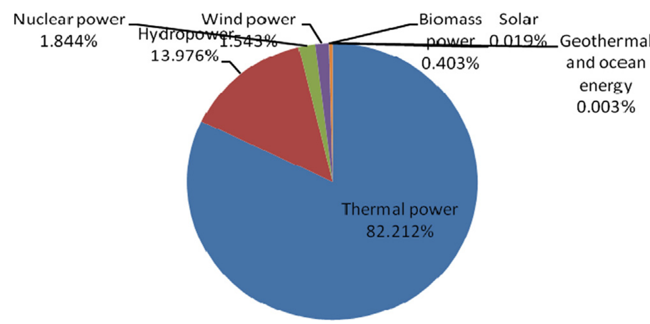



**Fig. 2.** Composition and proportion of China's power generation in 2011.

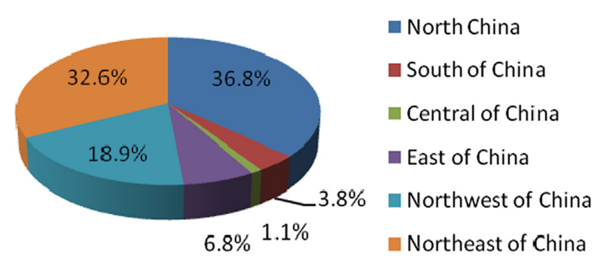



**Fig. 3.** Regional distribution of grid-connected wind power in 2011.

accounted for 82.2%, 14%, 1.8%, 1.5%, 0.02% and 0.4% respectively, as shown in Fig. 2. Overall, thermal power was the main source of power generation [11]. However, renewable energy power generation including hydropower accounts for 15.9% of total generation capacity in 2011. If hydropower is not considered as a king of renewable energy resource, the proportion of renewable energy power generation will be 2%. In the same year, the installed capacity of renewable energy accounted for 25% of the world's total installed capacity and power generation accounted for 20.3% of the world's electricity supply [12].

### 2.1. Overview of wind power industry development

By the end of 2011, China's lifting capacity of wind power has reached 56.38 million kW, which ranks first in the world for 3 years consecutively, of which construction capacity reached 49.21 million kW, and capacity connected to grid reached 46.23 million kW with an average annual growth rate of 85.8%, which has increased by 56.2% of that in 2010 and 22.1 times more than that in 2006 [13]. Besides, regional wind power capacity connected to grid of State Grid Corporation reached 44.47 million kW, accounted for 96.2% of the national wind power capacity and has increased by 22.4 times than that in 2006 with an average annual growth rate of 86.2% [14].

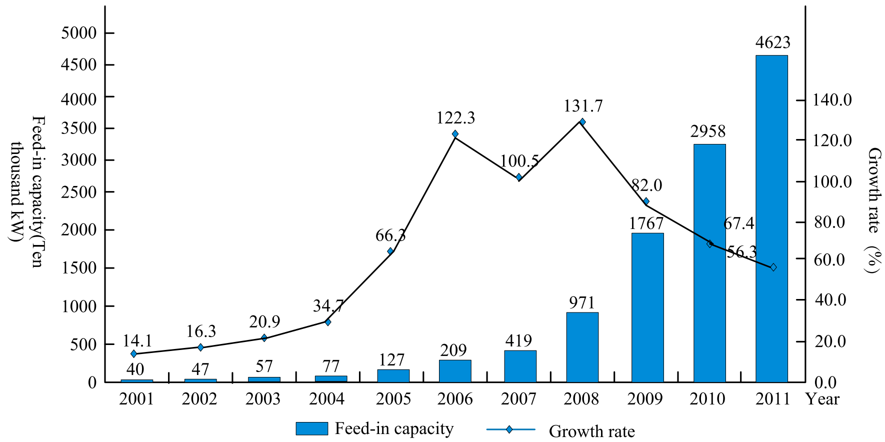



**Fig. 4.** Grid-connected capacity and its growth rate of China wind power in 2001–2011.

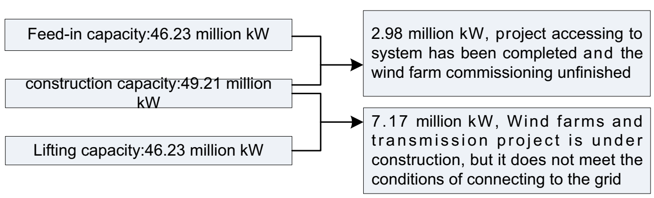



**Fig. 5.** China's wind power installed capacity by the end of 2011.

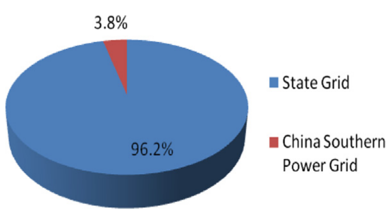



**Fig. 6.** Proportion of grid-connected capacity from State Grid Corporation and Southern Power.

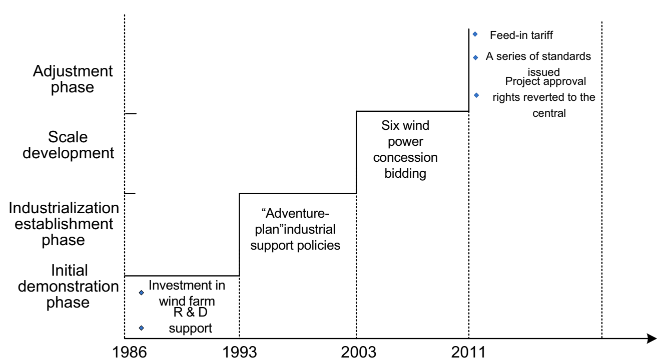



**Fig. 7.** Government's guidance mechanism for China's wind power development at different stages.

China's newly wind power capacity connected to grid reached 16.65 million kW with a year-on-year 14.2% of increase, of which 15.63 million kW was from State Grid Corporation, accounted for 93.9%. Capacity connected to grid in China's north, northeast, northwest, east, central and southern power grid are 17.01 million kW, 15.09 million kW, 8.72 million kW, 3.13 million kW, 520,000 kW and 1.75 million kW respectively [15]. Additionally, the capacity connected to grid of China's north, northeast, northwest together accounted for about 88% of the total national capacity connected to grid, as shown in Fig. 3. Fig. 4 shows grid-connected capacity and growth rate of China wind power in 2001–2011. Fig. 5 shows China's wind power installed capacity by the end of 2011. The ratio of

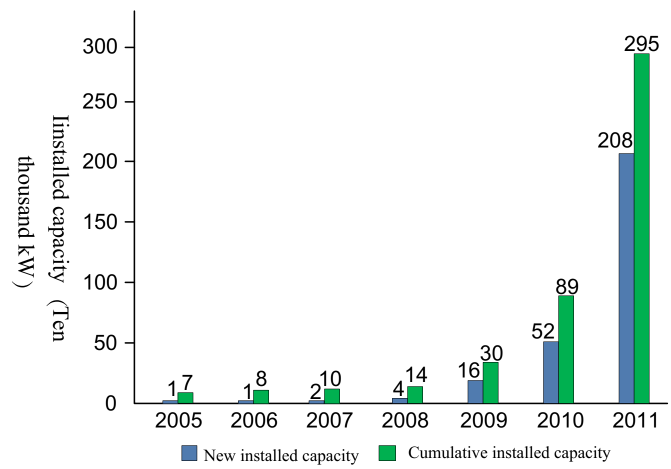



**Fig. 8.** Annual new installed capacity and total installed capacity of China's photovoltaic power from 2005 to 2011.

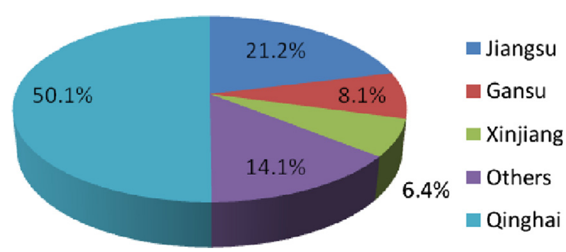



**Fig. 9.** The share of cumulative grid-connected capacity of large-scale photovoltaic power generation projects from China's primary provinces (regions) by the end of 2011.

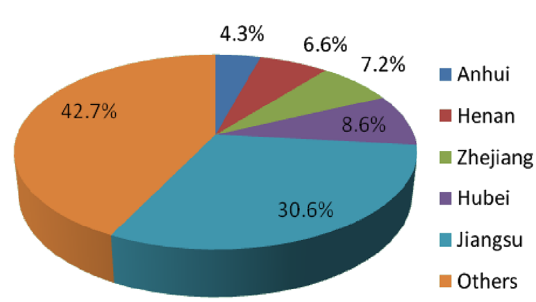
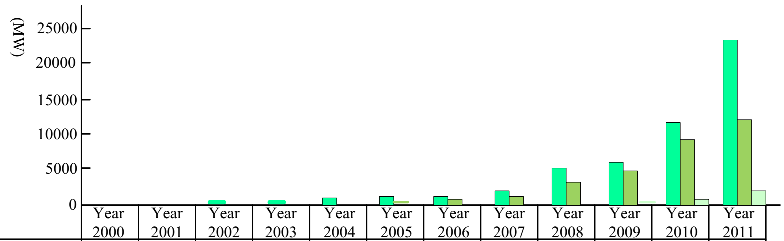



**Fig. 10.** The share of cumulative installed capacity of distributed photovoltaic power generation from China's primary provinces (regions and city) by the end of 2011.




| | Year 2000 | Year 2001 | Year 2002 | Year 2003 | Year 2004 | Year 2005 | Year 2006 | Year 2007 | Year 2008 | Year 2009 | Year 2010 | Year 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual new installed capacity in Europe | 53 | 94 | 142 | 201 | 708 | 1002 | 987 | 1972 | 5297 | 5803 | 13367 | 21939 |
| photovoltaic cells Production in China | 2.8 | 4.3 | 15.3 | 8 | 50 | 200 | 438 | 1088 | 2623 | 4011 | 9000 | 13018 |
| Annual new installed capacity in China | 0 | 11 | 15 | 10 | 9 | 4 | 12 | 20 | 45 | 228 | 520 | 2200 |

**Fig. 11.** Photovoltaic cells production, annual increase of installed capacity in China and an annual increase of installed capacity in Europe in 2000–2011.

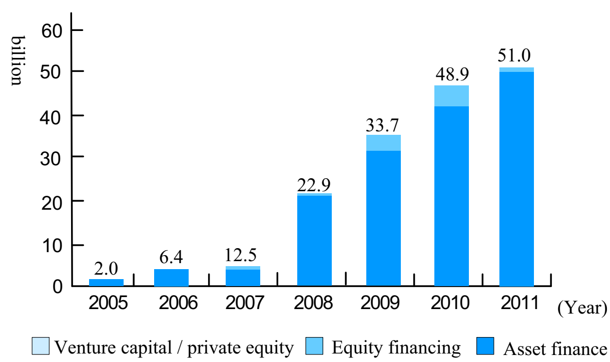



**Fig. 12.** Situation of China's renewable energy investment and financing.

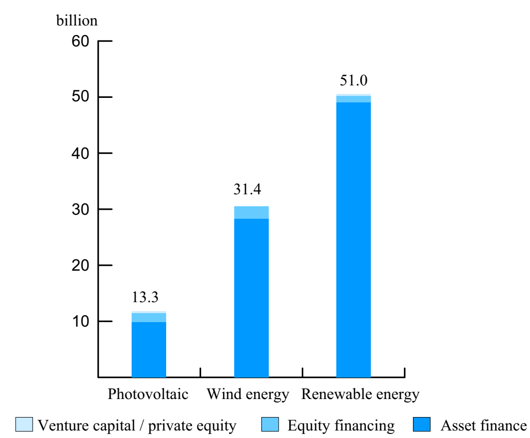



**Fig. 13.** Renewable energy investment composition of China in 2011.

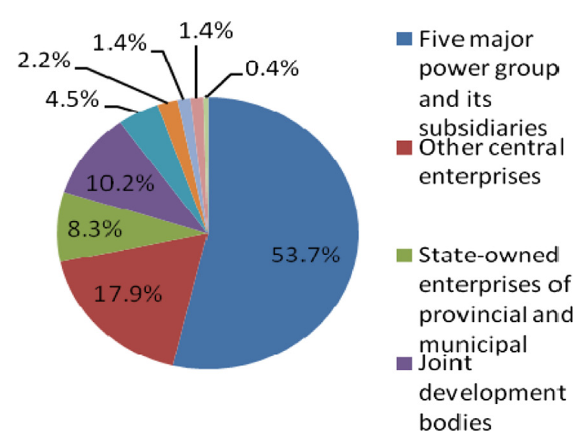



**Fig. 14.** Proportion of China's cumulative wind power installed capacity of all developers.

capacity connected to grid from State Grid Corporation and Southern Power Grid Company is shown in Fig. 6.

China's wind power market and the manufacturing sector has been developed under the guidance of the central government for a very long time. The development of China's wind power started in 1980s. By the end of 1989, the cumulative installed capacity has reached 4.2 GW. However, until 2011, the cumulative installed capacity has already climbed to 62.4 GW (grid-connected capacity reached 45 GW), ranking first in the world. Overall, the development of wind power in China has gone through four stages: initial demonstration phase (year 1986–1993), industrialization establishment phase (year 1994–2003), scale development phase (year 2004–2010) and adjustment phase (after year 2011) [16]. Fig. 7 shows the government's guidance mechanism for China's wind power development at different stages.

### 2.2. Overview of photovoltaic industry development

China's solar photovoltaic power generation system is mainly divided into three categories: large ground-based photovoltaic stations; photovoltaic power generation system of user-side (mainly including demonstration projects of solar photovoltaic building application and golden solar demonstration projects), off-grid independent photovoltaic systems and wind-solar energy complementary power generation projects. By the end of 2011, the cumulative installed capacity of China's photovoltaic power generation system will be approximately 300 million kW, ranking sixth in the world, in which installed capacity of ground-based photovoltaic stations will be approximately 200 million kW accounting for 2/3 and off-grid independent photovoltaic systems will reach 120,00 kW. In the same year, the cumulative grid-connected capacity reached 236 million kW with a year-on-year growth of 570% and the annual generation capacity reached 914 million kWh. Besides, new grid-connected capacity of photovoltaic power was 2.008 million kW with a year-on-year growth of 634%. Additionally, the grid-connected capacity of photovoltaic power from State Grid Corporation has reached 2.32 million kW with a year-on-year growth of 558%, 1.97 million kW more compared with that in 2010 [17]. The annual new installed capacity and total installed capacity of China's photovoltaic power during 2005–2011 are shown in Fig. 8. Fig. 9 illustrates the share of the cumulative grid-connected capacity of large-scale grid-connected photovoltaic power generation projects from China's primary provinces (regions) by the end of 2011. Fig. 10 shows the share of cumulative installed capacity of distributed photovoltaic power generation from China's primary provinces (regions and cities) by the end of 2011. According to "12th Five-Year Plan" for the development of solar power, to 2015, the installed

capacity of photovoltaic power generation will reach 20 GW, of which distributed photovoltaic power generation will be approximately 10 GW [18].

China's photovoltaic industry was in the prototype stage of development before 2000 and the price of solar cells was rather expensive. However, since 2000, Chinese government started to utilize photovoltaic power to supply electricity to people in remote areas. Many projects have been launched, like "Bright Project pilot project (2000)"and "projects of power transmission to the country-side project (2002–2003)", which leaded to the development of the domestic photovoltaic manufacturing [19]. China's photovoltaic manufacturing has experienced a high-speed development after 2004 driven by European market. In 2007, China became the world's largest producer of photovoltaic cells of which the power output is 1088 MW, as shown in Fig. 11. To the end of 2011, the total capacity of photovoltaic cells was about 40 GW, while the global photovoltaic installed capacity was only about 28 GW [20]. However, more than half of the photovoltaic production was postponed. Additionally, European countries began to substantially adjust the photovoltaic industry policies and launched the "anti-dumping, anti-subsidy" measures for China's photovoltaic products. because of these issues, Chinese photovoltaic manufacturing industry has met significant dilema. Thus, in this context, Chinese government began to draw up a series of measures to expand the distributed application of domestic photovoltaic industry.

## 3. Overview of renewable energy investment and financing

With the rapid development of renewable energy industry in China, the scale of renewable energy investment is increasingly expanding during these years. This section mainly analyzes the situation of China's renewable energy investment from the investment amount, developers, financing means, fund composition and financing channels.

### 3.1. Overview of renewable energy investment

Fig. 12 shows the situation of China's renewable energy investment and financing after 2005. China's renewable energy investment kept steady growing during "11th Five-Year" period. The total investment attained $124.4 billion with an average annual investment of $24.9 billion. In 2011, the investment in renewable energy sector has reached $51 billion [21]. Meanwhile, from the perspective of financing channels, venture capital/private equity decreased rapidly after 2008. However, the scale of equity financing was larger in 2007, 2009 and 2010, besides, the size and share of the assets financing kept increasing rapidly. During the year of 2011, asset financing accounted for 97.5% of the total investment, with equity of 2% and venture capital/private equity of 0.5% [22].

If we take the capital flow of investment in renewable energy into consideration, wind energy and photovoltaic are the main part of renewable energy investment (see Fig. 13). As for the $51 billion renewable energy investment in 2011, wind energy and photovoltaic accounted for 87.8%, while wind energy was 61.6% and photovoltaic investment was 26.1%. In addition, asset financing was a major part of wind energy and photovoltaic investment, respectively accounted for 89.8% and 85.7% of the wind energy and photovoltaic investment. Under the background mentioned above, this paper focuses mainly on wind energy and photovoltaic financing [23].

### 3.2. Investment and financing bodies

State-owned enterprises (including The Top5 Power Generation Groups and their subsidiaries, other central enterprises, provincial and municipal state-owned enterprises) are the main bodies to exploit wind power market, which respectively accounted for 80% and 84.3% of the cumulative wind power installed capacity and the total installed capacity of 2011. Moreover, their share of installed capacity continued to expand in 2011, as shown in Figs. 14 and 15. The Top5 Power Generation Groups and their subsidiaries are overwhelmingly dominant in all state-owned enterprises [24]. More than 60 state-owned enterprises all over the country (excluding subsidiaries) were involved in the construction of wind power by the end of 2011. Meanwhile, joint exploitation bodies accounted for 6.7% of newly installed capacity in 2011. At the same time, private enterprises, foreign-funded enterprises and Sino-foreign joint ventures enterprises respectively accounted for 3.2%,

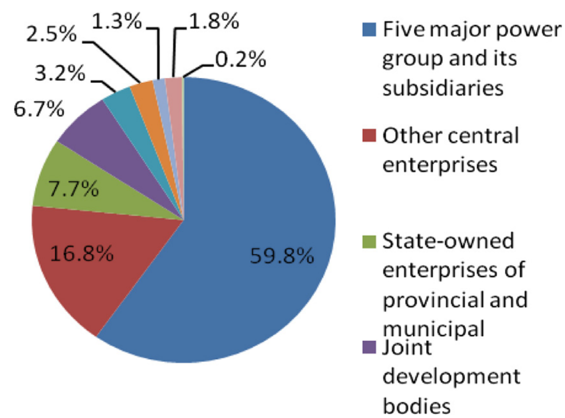



**Fig. 15.** Proportion of China's wind power installed capacity of all developers in 2011.

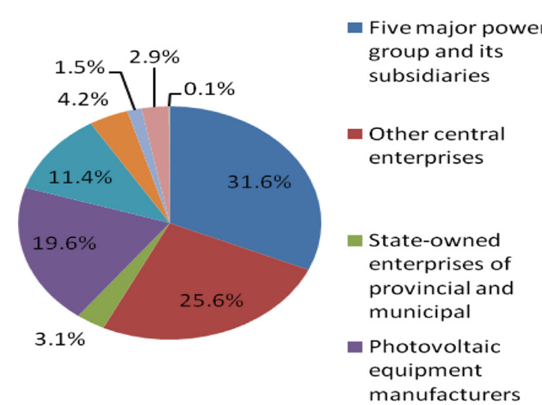



**Fig. 16.** Proportion of China's cumulative photovoltaic power installed capacity of all developers.

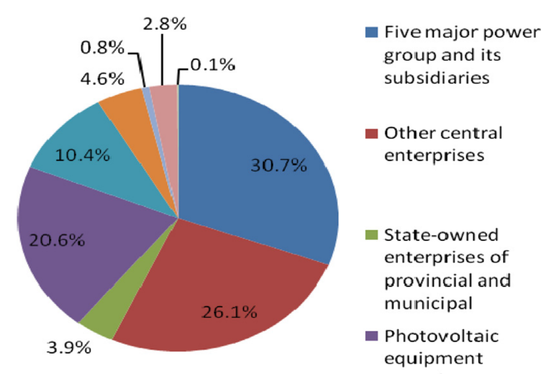



**Fig. 17.** Proportion of China's photovoltaic power installed capacity of all developers in 2011.

1.8% and 0.2% of the domestic market. Moreover, wind power equipment manufacturers accounted for 2.5% market [25].

Compared with the wind power market, the developers of photovoltaic power market are much more dispersed, as shown in Figs. 16 and 17. State-owned enterprises (including The Top5 Power Generation Groups and their subsidiaries, other central enterprises, provincial and municipal state-owned enterprises) accounted for the cumulative photovoltaic installed capacity and newly installed capacity 60.3% and 60.7% in 2011 [26]. The Top5 Power Generation Groups and their subsidiaries occupy slightly larger in the state-owned energy companies, while the share of provincial and municipal state-owned enterprises is quite insufficient. As for newly installed capacity of photovoltaic power in 2011, the market share of photovoltaic equipment manufacturers was 20.6%, joint exploitation bodies was 10.4%, private enterprises and foreign-funded enterprises was 4.6% and 2.8% respectively [27].

### 3.3. Financing means

As for financing means of China's wind power and photovoltaic power, it mainly includes corporate financing, project financing, and financing lease. Meanwhile, During the past decade, the means of financing has developed in a variety of directions. However, compared with developed countries, China's means of financing are relatively backward. Listing and issuing bonds on behalf of projects for financing do not ever appear and third-party financial service providers for professional financing services are also lacking.

#### 3.3.1. Corporate financing

China's large enterprises, especially state-owned enterprises prefer the way to corporate financing. For instance, China Longyuan Power Group was listed in Hong Kong for financing in December 2009 with collecting money 17.7 billion RMB, the investment was separated into the following ways: 50% of the total amount was used for investment in wind power projects, approximately 20% for repaying bank loans, about 10% for purchasing foreign wind power equipments, approximately 10% for investing Xiongya company. At last, the rest 10% for general operating capital [28].

#### 3.3.2. Project financing

Project financing has become one of the important means of financing for the Chinese state-owned enterprises such as China Longyuan Power. For the foreign-funded enterprises like China Wind Power Group, project financing is also the most important financing means. A common way to project financing is BOT, a business means adopted by wind turbine manufacturers, such as Goldwind, Huayi, Hunan wind power.

#### 3.3.3. Financing lease

Finance lease is one of the significant financing means for the developing China's renewable energy. Mingyang Wind Power Company established finance leases company in 2009, creating a new business way. This company has reached a strategic cooperation agreement with three of the whole country's 10 bank-based financing leasing companies. The financing lease reached $25 billion in 2011, accounted for 30% of the total annual input.

### 3.4. Project funding sources

There are three main sources of funding for wind power projects and photovoltaic power projects: enterprise investment capital; bank loans and central government investment subsidies. For wind power generation projects, the project funds consist of capital and bank loans, and the proportion is 20% and 80% respectively.

The photovoltaic power project can be divided into two types: centralized and distributed. Centralized photovoltaic power project funds are related to the type of developer. Given that the developer is a state-owned enterprise, generally 20% of project funds are capital and 80% are bank loans. If the developer is photovoltaic manufacturer, generally 100% of project funds are capital with no bank loans. Distributed photovoltaic power system is supported by photovoltaic subsidy policies; the proportion of the subsidy is 30% capital, 20% bank loans and 50% government subsidies. For photovoltaic projects developed only by photovoltaic manufacturers in 2011, 50% was capital and 50% was government subsidies [29]. Investment composition of wind power and photovoltaic power projects in 2011 is shown in Table 2.

### 3.5. Financing channels

The main financing channels for China's wind power and photovoltaic power developers are bank loans, stock market, bonds, etc.

**Table 3**
Financing situation of listed developers of wind power and photovoltaic power.

| Enterprises | Exchange | Time | The amount of fund-raising (100 million RMB) |
|---|---|---|---|
| China Longyuan Power | HKEx [Hong Kong, China] | 2009-12-10 | 177.1 |
| Suntien Green Energy | HKEx [Hong Kong, China] | 2010-10-13 | 28.3 |
| Datang Renewable | HKEx [Hong Kong, China] | 2010-12-17 | 45.4 |
| Huaneng New Energy | HKEx [Hong Kong, China] | 2011-06-10 | 55.1 |
| Huadian Fuxin | HKEx [Hong Kong, China] | 2012-06-28 | 21.8 |

**Table 2**
Proportion of investment compositions of wind power and photovoltaic power projects in 2011.

| Projects | Installed capacity of 2011 | Total investment | Capital | | Bank loans | | Central government subsidies for photovoltaic power projects | |
|---|---|---|---|---|---|---|---|---|
| | GW | (billion) | (billion) | Proportion(%) | (billion) | Proportion(%) | (billion) | Proportion(%) |
| Wind power | 17.6 | 28.2 | 5.64 | 20 | 22.56 | 80 | 0 | 0 |
| Photovoltaic power | 2.331 | 11.4 | | | | | | |
| Centralized power | 1.909 | 10.23 | 2.79 | 27.2 | 7.45 | 72.8 | | |
| Distributed generation | 0.422 | 1.17 | 0.48 | 40.7 | 0.11 | 9.2 | | 50 |
| Total | | 39.6 | 8.9 | 22.48 | 30.11 | 76.04 | 0.58 | 1.47 |

Bank is the main financing channel. By the end of 2011, a total renewable energy loan amount issued by banks was about 300 billion RMB, of which the largest share was China Development Bank. The cumulative loans for wind power, solar power, biomass power generation loans were 114.9 billion RMB. The installed capacity supported by China Development Bank has exceeded 15 GW, more than 1/3 of total installed capacity. The proportion of centralized wind power and photovoltaic power projects loans to the total investment is generally 80% [30].

Since 2009, stock financing has become a popular financing channel for developers. Listed enterprises in this sector have raised 32.77 billion RMB in total by the end of June 28, 2012, shown in Table 3.

Bond issue has become an important financing channel since 2010. Among all the renewable energy developers, China Longyuan Power Group and China Wind Power Group have raised 17.63 billion RMB through issuing bonds during 2010–2011. Besides, China Longyuan Power Group issued 6.16 billion RMB bond in 2010, and 6.16 billion RMB in 2011. In 2011, bond financing contributed 19.4% to the company financing amount, and China Wind Power Group released 750 million RMB offshore bonds with coupon rate of 6.375% [31].

## 4. Renewable energy financing mode and its features

This section focuses on wind power and photovoltaic power financing and their financing ways. On this basis, wind power and photovoltaic power financing mode features are summarized as well as the comparison between this two financing modes.

### 4.1. Wind power financing mode

China's wind power financing mode is typically government-oriented, as shown in Fig. 18. The main stakeholders consist of the central government, developers (mainly state-owned energy companies), wind turbine manufacturers, local governments, banks and capital markets. The central government is the conductor for guiding various stakeholders to participate in the exploitation projects of wind power projects through a series of policy measures. Besides, wind developers are active participants and benefit from wind power projects investment. At the same time, banking and capital markets are the receivers of policy signals while local government is an active participant and a promoter in the wind power market with the resources in exchange for local economic development.

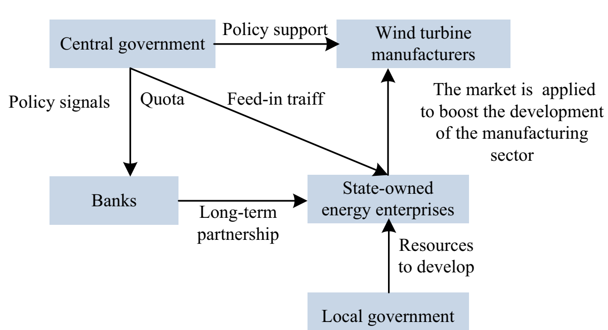



**Fig. 18.** Wind power financing mode.

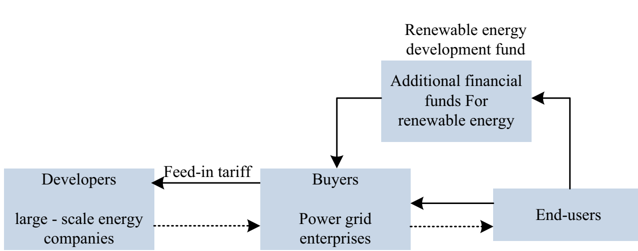



**Fig. 19.** Establishment of renewable energy power market.

#### 4.1.1. Conductor

Central government, as the conductor of wind power market, is not only a leader to establish market mechanism, but also an initiator which integrates stakeholders to participate in.

The central government establishes the renewable energy market through a series of policies and explicitly identifies the buyers of electricity market as well as developers. Meanwhile, funding sources of electricity price subsidies and electricity price will also be decided by the central government, as shown in Fig. 19. The purchasers of renewable energy power includes grid companies, the original developers were various types of enterprises organized by the government, and later the market share of grid companies and large-scale state-owned energy companies is clarified. Renewable energy electricity subsidy funds were originally sponsored by the former State Power Corporation, but later they were assumed by all the electricity end-users through paying renewable energy surcharge [32]. For electricity tariffs, approval tariff will be changed to bidding pricing for reference. Moreover, national wind power feed-in tariff was launched in 2009. So far the various elements of wind power market were created by the central government through a series of policies, laying a solid foundation for the market-oriented development of wind power financing.

Central government has been kept exploring ways to encourage renewable energy stakeholders to participate in the relative projects. Besides, the government has been actively establishing renewable energy market as well. For instance, developers, governments and banks are the main participants in wind power financing, and each of them also possesses a lot of resources to participate in and influence the exploitation of wind energy. Huge market forces are formed under the participation of three parties,

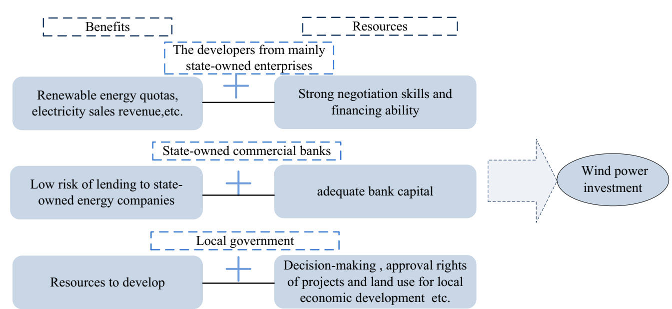



**Fig. 20.** Benefits and resources of key participants for wind power financing.

**Table 4**
Internal rate of return of for each regional wind farms in 2009.

| Region | All investments IRR (without CDM) | Capital IRR (without CDM) | All investments IRR (with CDM) | Capital IRR (with CDM) |
|---|---|---|---|---|
| Northeast | 6.4–6.9 | 8–9 | 8.1–8.2 | 9–10.3 |
| North China | 6.2–7.0 | 8–9 | 8–8.2 | 8.8–9.8 |
| South China | 6.0–6.6 | 7.8–8.8 | 8–8.4 | 8.5–9.5 |
| Northwest | 6.2–8 | 8–10 | 8.3–9.6 | 8.8–10.5 |

jointly promoting wind power financing, which is shown in Fig. 20.

#### 4.1.2. Active participants

Wind power developers are active participants in wind power projects, at the same time, the participants also benefit from participation. Wind power developers' incomes mainly include electricity sales revenue, CDM, land revenue and other additional benefits. According to the National Development and Reform Commission statistics (see Table 4), the average full internal rate of return for national wind power projects was approximately 7% in 2009, while the rate was slightly higher in Northeast and North China. Despite the abundant wind resources in northwest, rate of return was not high due to the limited transmission capacity, frequent brownouts. In addition, wind power and solar power projects are able to proceed under tax relief. According to the announcement of central government in 2008 that corporate income tax of wind and solar power projects for the first 3 years in the period of project was free and the following 3 years was 50%. Meanwhile, wind and solar power projects could be precede

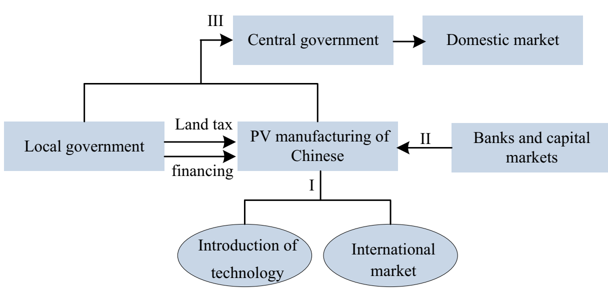



**Fig. 21.** Photovoltaic financing policy model.

under 50% value-added tax rebates. In addition to the preferential policies above, some local governments also provide preferential land utilization policies as well. For instance, the second-stage wind farm of Tuscaloosa EMin tamar of Xinjiang contains 49.5 MW generation capacity, 2.3 km$^2$ project construction land, 50 years' land use term and transfer price of 1.98 million RMB, however, due to the lack of the covering area for wind turbines, the remaining land can still be used for other purposes [33].

#### 4.1.3. Policy signals receivers

Banking and capital markets are policy signals receivers. During the "11th Five-Year" period, the central government pushed forward medium or long term planning and various supporting policies for the development of renewable energy as an emerging strategic industry, giving a clear policy signal to capital markets. In addition, the release of wind power tariff has ensured the benefits of wind power projects and strengthened the banking and capital market's confidence of wind power developers.

The central government encourages state-owned commercial banks to provide favorable and low-interest debt financing loans for those companies engaging in renewable energy generation business. State-owned wind power developers can easily get bank loans under current policy situation and credit guarantees. For example, in 2011, the bank loan size of Longyuan Power, Huaneng New Energy and Datang was 27.795 billion RMB, 13.536 billion RMB and 78.77 billion RMB respectively, accounted for 57%, 71.5% and 51.2% of new energy financing. The weighted average financing cost of Longyuan Power Company was 15% less than benchmark interest rate for bank loans for the same period during 2010 [34].

The stock market also received a clear policy signal in wind power development. There were 15 wind power manufacturing

**Table 5**
Development phase of photovoltaic power.

| Stage | Means | Content |
|---|---|---|
| The first stage (year 1998–2004): initial stage of photovoltaic industry | Dominated by the local government | The local government provides much support like land, taxation and financing for the initial development of photovoltaic manufacturing. State-owned enterprises like Wuxi Little Swan Company are introduced by Wuxi municipal government which aimed at the financing for newly established Suntech Company in 2002. A total of $6,000,000 was invested to Suntech Company, accounting for 75% stake of the company |
| The second stage (year 2005–2011): growth stage of PV industry development | Market-driven and profit-driven capital poured into the industry | Venture capital/private investment for photovoltaic manufacturing was $2.121 billion. In addition, PV manufacturers totally issued 11 bonds, with total proceeds of $1.55 billion |
| The third stage (after year 2012): expansion of domestic photovoltaic applications market stage | Driven by photovoltaic manufacturers and local governments together | After the loss of more than 70% of total market share in US and European markets, the capital fled photovoltaic manufacturing industry causing the industry generally facing funding strand breaks, bankruptcy and the risk of failure. After September 2012, the central government has introduced a number of measures to expand domestic PV market applications, digestive photovoltaic industry capacity |

**Table 6**
Polices issued for the expansion of domestic photovoltaic applications market since September 2012.

| Policies or documents | Time | Department |
|---|---|---|
| "Notice about declaration for demonstration area of distributed photovoltaic large-scale applications" | 2012-09-14 | National Energy Board |
| "Recommendations on further strengthening the financial and credit to support the healthy development of PV industry" | 2012-09-25 | China Development Bank |
| "Suggestions on the services for distributed photovoltaic (PV) into grid" | 2012-10-26 | State Grid Corporation |
| "Notice on declaration for gold sun and photovoltaic building application demonstration project-startup the second batch of 1GW demonstration projects for 2012" | 2012-11-07 | Ministry of Science and Technology, Ministry of Finance, the National Energy Board |

listed companies raising $4.72 billion in total from 2006 to August 16, 2012. China Longyuan Power, SUNTIEN, Datang new energy, Huaneng New Energy successively listed, raising $4.55 billion in total since 2009 [35].

#### *4.1.4. Economic development at the expense of resources*

Local governments are active participants in the exploitation of wind power. For local government, wind power development is one of the important means to increase investment, develop specialty industries and stimulate employment. In addition, tax revenue created by wind farms construction and wind turbine manufacturing industry is able to be an important source for local government's financial income. Local governments have introduced relevant policies to promote wind power applications to drive the development of manufacturing. For instance, in the document of "New energy industry restructuring and revitalization plan of Jiangsu", Jiangsu should exploit the advantages of existing industries to the full. The scale construction of wind farms can drive the development of wind power equipment industry so as to promote industrial standardization, serialization, develop wind power generation and construct wind power equipment manufacturing bases. Moreover, wind power equipment sales revenue reached 80 billion RMB in 2011 and realized machine manufacturing capacity of 4 GW.

### *4.2. Photovoltaic power financing mode*

The development of photovoltaic can be divided into three stages according to the financing characteristics (see Fig. 21): The first phase (year 1998–2004) was the phase of photovoltaic industry construction; the second phase (year 2005–2011) was the development and growth stage of photovoltaic power industry; the third phase (after 2012) was the expansion of domestic photovoltaic applications market. The development mode and the specific contents of each phase are shown in Table 5.

Photovoltaic manufacturing financing was driven by the local government in its infancy. During the next few years, the high profit margins attracted substantial capital to pour into photovoltaic industry, in which local governments have played a positive promotion role. After an explosive growth, photovoltaic industry generally faced desperation situation for the breakdown of fund chain. After 2011, a large amount of capital was withdrawn from the photovoltaic manufacturing along with bubble burst within photovoltaic industry. Photovoltaic financing policy model is shown in Fig. 21.

#### *4.2.1. Main promoters*

The manufacturers and local governments are main promoters. Photovoltaic manufacturers are active market pioneers. In 2011, the proportion of photovoltaic manufacturers of newly photovoltaic market in China domestic is 21%. China's photovoltaic industry was driven by private enterprises. Hereafter, this industry has experienced a difficult start since year 2000 or so. Local government is also one of the main promoters. On one hand, local governments can actively support the development of local photovoltaic manufacturing, providing preferential policies in relation to land, taxation, research and development support, so as to create a sound financing and development environment for photovoltaic industry. On the other hand, local governments also actively issue policies to promote photovoltaic applications in order to drive the development and applications of local manufacturing.

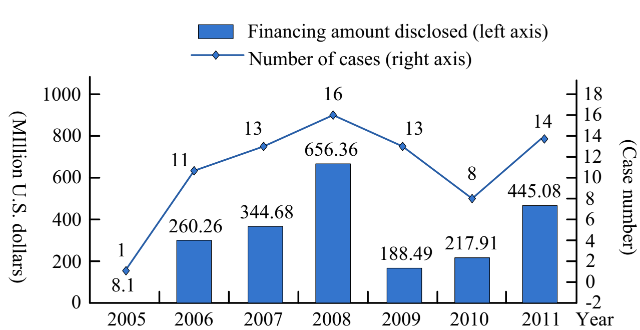



**Fig. 22.** The VC/PE financing scale of photovoltaic industry enterprises in 2005–2011.

#### *4.2.2. Passive leader—central government*

The central government is a passive leader. With wind power technology becoming more mature, the central government gives key support to wind power development after 2003. Before "the 11th Five-Year", central government has just set up projects related to photovoltaic power technologies in the research. In 2012, China's photovoltaic industry lost their US and European markets, which has caused enormous challenges to photovoltaic industry development. Under the request of multi-parties like photovoltaic manufacturers and local governments, the central government, on one hand, have actively mediated and negotiated with EU; on the other hand, it was also ready to expand the size of domestic market rapidly. In September 2012, central government densely launched a series of intensive market-based measures to expand domestic applications, shown in Table 6.

#### *4.2.3. Capital suitors*

The banks and capital market are capital suitors. Before 2011, profit-driven features have attracted banks and capital market to invest in photovoltaic manufacturing. During the year of 2005, high profits of photovoltaic manufacturing drove the development of investment from venture capital/private equity. Fig. 22 shows the VC/PE financing scale of photovoltaic industry enterprises in 2005–2011. In 2007, there was a wave of photovoltaic enterprises listing and financing. In 2010, 10 photovoltaic manufactures such as Yingli, LDK Solar, Suntech. After 2011, photovoltaic manufacturing industry is faced with huge losses, followed by a continuing credit overdue. Even some enterprises faced the problems of over old debt, default interest and the increasing of nonperforming loans and other issues. After August 2012, mass stock market capital was withdrawn from China's photovoltaic manufacturing. By the end of October 18, 2012, in nearly in a month, the stock of Chinese photovoltaic companies listed in the US was hovered at $1. Investors' enthusiasm in photovoltaic investment sharply plummeted in 2012. In the third quarter of 2012, environmental protection energy conservation industry disclosed only four cases with total investment amount of $52.8 million, which was less than 1/6 of maximum 335.4 million RMB in the first quarter in 2011 [36].

### *4.3. A comparative analysis between wind power and photovoltaic financing modes*

From the above analysis, the main differences between wind power and photovoltaic power are the financing mode.

From the perspective of financing, the projects of centralized wind power and photovoltaic power are similar, which are basically supported by large-scale enterprises and banks. However, the financing mode of distributed photovoltaic power projects is varied in different aspects. In distributed generation system, the share of internal capital, bank loans and government subsidies are 30%, 20%, and 50% respectively, because of the subsidies from the central government. As for the policy formulation and implementation mechanism related to financing mode, photovoltaic power is quite different from wind power [37]. The financing mode of photovoltaic power is driven by the manufacturers, while wind power is led by

**Table 7**
Comparative analyses analysis between financing mode of wind power and photovoltaic power financing mode.

| Comparison content | Wind power financing | Photovoltaic financing |
|---|---|---|
| Financing means | Government-oriented financing | Manufacturers to promote financing |
| Role of central government | Active guides | Passive leaders |
| Role of local government | Active participants | Active promoters |
| The role of the banking and capital markets | Receivers of policy signal | Capital suitors |
| Role of manufacturers | Active participants | Promoters |
| Development means of manufacturing sector | Domestic market | Overseas market |
| The support from domestic market | Yes | No |
| Policy formulation | The central government has a clear development strategy | The impact of PV manufacturers and local governments |
| Policy implementation | Under clear policy guidelines, government, developers, banks have formed a tremendous synergy, and jointly development mode of wind power | A distributed generation power grid accessing barrier still exists. Under the promotion by PV manufacturers and local governments, State Grid Corporation pushed by the central government expressed support for distributed photovoltaic power generation system connected to the grid |

the government, shown in Table 7. Although both photovoltaic and wind power are heavily dependent on policy support and government-oriented financing. However, the central government is rather passive in photovoltaic power financing, but an active leader in wind power.

For wind and photovoltaic power, the policy formulation and implementation mechanism related to financing modes are quite different. For the development of wind power, firstly, the central government formulates policies, followed by the response from enterprises, local governments, banks and capital market. Thus a policy implementation mechanism which is actively and jointly promoted by each party is generally formed. The development of photovoltaic power is a bottom-up of enterprise–local government pilot mode. The response of enterprises and local governments has a great impact on the policies formulated by the central government. From the perspective of policy implementation, there is a biggest obstacle for distributed generation connected to grid. However, enterprises and local governments will push the central government to solve this problem. In October 2012, State Grid Corporation indicated that the photovoltaic power system less than 6 MW can be free connected to grid, this measure has opened the door for domestic distributed generation market.

## 5. Issues and countermeasures

China's wind and photovoltaic power industries have achieved rapid development under the impetus of renewable energy investment and financing. However, some issues become more and more prominent along with the rapid development of renewable energy during the "11th Five-Year" period, such as single financing channel, complex application and approval procedures for projects, policy imperfections and imbalance development of industry chain, etc. These issues will be discussed deeply in this section, and some feasible countermeasures will be further proposed.

### *5.1. Issues and countermeasures of wind power investment and financing*

The major issues of government-oriented wind power investment and financing in this stage are

(1) Wind power financing channel is relatively single. Firstly, for the current situation of wind power projects, at least 80% of the funds rely heavily on debt financing, among those, the largest part is indirect financing, with capital of only 20%. Massive debt financing leads to high long-term debt ratio of wind power enterprises, excessive pressure of debt service and fragile capital chain probably increases financial and operational risks. Therefore, it is imperative to optimize financing means and broaden financing channels. Secondly, for wind power project financing channels, the proportion of equity financing is low while debt financing is high. International loans, dominated by foreign government loans, is accounting for high proportion of debt financing. This single financing channel is not conducive to the long-term development of wind power industry.

(2) Insufficient perfect project approval system. On one hand, the complicated application, approval procedures and processes of wind power projects result in the high pre-project costs and transaction costs. The approval procedure of wind power project is at least 1 year, up to 2–3 years. The average cost of each wind power pre-project is 2–3 million RMB. The application procedure for project approval barely to provincial Development and Reform Commission needs to be further simplified to reduce the uncertainty of project applications, shown in Fig. 23. The time, manpower, money at pre-project stage and uncertainty risk of project application limits the access of participation of medium-sized and small enterprises. Thus, due to the higher pre-project costs and transaction costs, developers tend to develop large-scale projects in order to increase expected earnings. On the other hand, "wind abandoned" phenomenon and project approval problem coexist. From January to May in 2012, the number of generation projects approved by Development and Reform Commission are totally 131, of which nearly 95% were wind power projects and approved through CDM projects, the situation of coexist of not fully utilized wind power and the unrational project approval [38]. The issue of accessing to the grid was never taken into consideration before the startup of the project, which results in the difficulty of wind power integration, serious phenomenon of "wind abandoned" and wind turbines left unused. There even occurred a phenomenon in some regions that the project was approved by local government but then resale to another party.

(3) Higher policy risks. Firstly, big risks in China's wind power feed-in price and the design still exists, as well as the implementation and supervision of related policies. The lack of service life and adjustment measures of feed-in tariff for the tariff policies has brought great uncertainty to policies. Therefore, banks were unwilling to support financing for medium-sized and small renewable energy projects due to policies

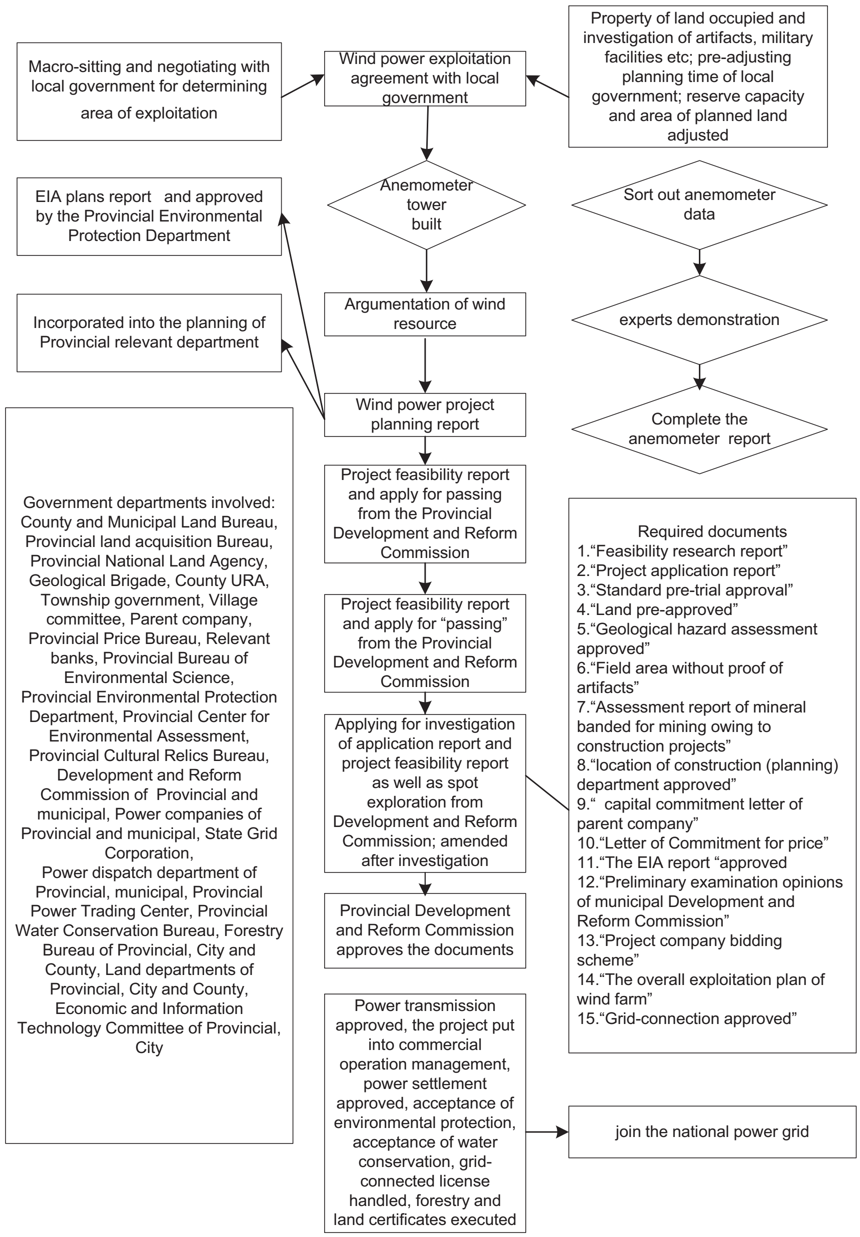



**Fig. 23.** Current wind power project application process.

changing risks. Secondly, the electricity fees settlement risk in the related policies, especially in the western region exists. As for 10 MW photovoltaic power station named Medium Energy of Shizuishan, the settlement price of this station has been 0.25 RMB/kWh with the grid company since the end of 2009 (the local coal desulfurization feed-in tariff) [39]. Additionally, the payment procedure for electricity billing subsidies is too complicated, it nearly needs six months or even a year to settle accounts in western region. However, these plants tend to have about 80% of loans, facing much pressure for monthly repayment. The slowness of subsidies payment would lead to funding difficulties for these enterprises, even caused the collapse of some private enterprises.

The following countermeasures are put forward in view of the above problems:

(1) Expanding financing channels for wind power. Firstly, it is necessary to establish diversified financing channels where direct and indirect financing is complementary. Ways of capitalization like issuing stocks and longer-term bonds can be considered in order to expand direct financing channels of wind energy industry. What is more, private capital and social capital can be accessed to the funding of wind power industry, such as establishing special loans and using third-party financing model, which was learned from the experience of developed countries, Secondly, a complete financing system should be established, including wind power project financing, commercial bank green credit, wind power investment fund under energy conservation program of international financial institutions and business bond financing, wind turbine equipment leasing, carbon finance and its derivatives as well as power options market.

(2) Establishing a thorough approval mechanism for wind power projects. On one hand, for the purpose of solving the disorder situation of wind power projects investment, governments and enterprises should strictly audit the feasibility and earnings of projects and control the project investment, avoid

duplicate construction of many projects. On the other hand, project application and approval processes should be simplified. Different application and approval procedures can be formulated according to the size of wind power system. For the applications from individual users system, the application and approval procedures can be eliminated. The procedures for small-scale decentralized/distributed system can be simplified, while those for the large-scale can be standardized, which can improve the efficiency of wind power project approval and reduce transaction costs.

(3) Reducing policy risk. Firstly, service life of feed-in tariff policies should be clearly defined, so the stability of renewable energy tariff within a certain period can be guaranteed. Therefore, the reduction of banks' risks stemmed from tariff policy changes will boost banks' enthusiasm for wind power project financing of small and medium-sized enterprises (SMEs), and eliminate policy barriers for the entering process of SMEs. Secondly, for the settlement risks from relevant policies, on one hand, innovative tariff settlement needs to be actively employed. For instance, drafts agreements for interest discounted can be applied to pay for electricity bill, which can relieve pressure on cash flow, reduce financing interest costs and also relieve tariff recovery pressure for grid companies. On the other hand, it is essential to strengthen supervision on surcharge levied of wind power tariff, quota trading and electricity bill as well as subsidies settlement and resolutely investigate, Besides, illegal electricity bill settlement should be rectified to ensure that additional subsidies for renewable energy tariff are timely and fully paid to relevant enterprises.

### *5.2. Issues and countermeasures of photovoltaic power investment and financing*

For the manufacturer-driven photovoltaic power investment and financing mode at the present stage, the main issues are as follows:

(1) Small and medium photovoltaic power generation projects are short of financial support, which affects sustained and balanced development of the entire photovoltaic power industry. On one hand, for the total investment of photovoltaic SMEs, the capital for this kind of projects are inadequate and mainly rely on bank loans. Thus, investment risk is overmuch concentrated in banks without the policy and financial support from government or other third parties. However, banks must control operational risks, which will result in much more difficulties for photovoltaic SMEs financing. On the other hand, generally, small and medium photovoltaic projects loans will face high cost and risks. What is more, in the early completion stage of construction of photovoltaic projects, repayment ability of enterprises is poor, under specific situation the investment will also become deficit. Accordingly, commercial banks have to be cautious about the loans. Then investors, rely on bank loans, are more inclined to invest in larger and state-supported solar photovoltaic projects, and they are unwilling to invest in those projects that are small and medium size or not included in the national demonstration projects. All these will ultimately hinder the healthy development of photovoltaic power industry.

(2) Imbalance investment structure results in imbalance development of the entire photovoltaic power industry. The development of China's photovoltaic manufacturing industry is a replication mode due to the expansion of production scale brought by investment. The substantial capital has entered photovoltaic manufacturing industry lured by high profits since 2010. Several major battery manufacturers also doubled the size of their scale to increase production. Throughout the solar photovoltaic industry chain, component packaging sectors, with the characteristics of less investment, short construction period, low technical and financial barriers and proximity to the market, has attracted a large number of production enterprises. However, overinvestment and competitive pressures will lead to production structural surplus of photovoltaic manufacturing industry. On the other hand, given component as a boundaries center, most enterprises focus on cells, ingot, silicon manufacturing, while the investment to the downstream industry chain, photovoltaic power system, is seriously inadequate, which causes the imbalance development of the entire photovoltaic power industry chain, namely, there is much investment in the upstream and insufficient investment in the downstream of the industry chain.

(3) The support policies for investment and financing are not imperfect. Firstly, there are many regulations like “trial” and “temporary” in the “Renewable Energy Law” and its relevant supporting policies, which has caused the uncertainties in feed-in tariff of photovoltaic industry. Investors will thereby be full of doubt about the stability of electricity prices and whether they can achieve the desired profit when they invest in photovoltaic power industry. Secondly, the supporting incentives like investment subsidies and tax incentives are still inadequate.

The issues of photovoltaic power investment and financing can be addressed from the following three aspects:

(1) Impetus to bank loans for small and medium photovoltaic power enterprises and encouragement for financial innovation. On one hand, according to the experience of Germany and Japan, it is essential to play the role of Chinese policy banks in those industries and fields that are in line with national industrial policies and socio-economic development. Policy banks, with the characteristics of low interest rates, strong policy support and publicity, are greatly suitable for China's small and medium sized photovoltaic power enterprises. It is suggested that China's policy banks should establish priorities loan system for photovoltaic power investment and simplify loan application process in order to provide financial assistance for small and medium photovoltaic power enterprises. On the other hand, the financing problems for small and medium sized photovoltaic power enterprises can be resolved through ways like the development of third-party financing, venture capital and leasing. The development of these ways should be stimulated as well.

(2) The reduction of excessive investment in photovoltaic manufacturing industry and promotion of the balanced and healthy development of this industry chain. Rational production capacity expansion and allocation of resources with respect to photovoltaic manufacturing enterprises should be guided through various means like financing conditions, environmental requirements and government subsidies. Meanwhile enterprises should be encouraged to focus on developing high-tech products with independent intellectual property rights, thereby enhancing international competitiveness.

(3) Development and implementation of strong workable incentives for investment and financing. Firstly, preferential tax can be rendered to relevant enterprises. Imported equipments of photovoltaic manufacturing enterprises for research and experimental purposes can be granted import duty exemptions and concessions. Additionally, it is suggested that for those enterprises which sell and install solar photovoltaic systems, the income should be exempted from sales tax.

Secondly, the acquisition of solar photovoltaic power should be encouraged. It is proposed that the acquisition policy of differential pricing nationwide can be implemented or feed-in tariff policy, namely, the national grid have to fully purchase solar photovoltaic power connected to grid at a fixed or incentive price and the price over conventional tariff can be subsided by state financial or shared equally by end consumers of electricity. Thirdly, related loans should be provided for those families having "roof generation plans" in order to reduce the risk of poor sales of photovoltaic products. Thus, most families have the ability to purchase PV modules and thereby there is a much larger market for photovoltaic products.

## 6. Conclusion

The exploitation and utilization of renewable energy sources is not only in an urgent need for China's current energy structure adjustment, energy conservation, rational control of total energy consumption, but also the inevitable choice for the sustainable utilization of China's future energy and transformation of economic development. During the "12th Five-Year" period, the newly installed capacity of wind power generation will be 70 million kW with total investment demand of 530 billion RMB. Besides, 20 million kW installed capacity of newly solar power will have 250 billion RMB of total investment demand. During the same period, the estimated investment demand of renewable energy will reach approximately 1.8 trillion. Firstly, in this context, the overview for the development of China's renewable energy industry was elaborated and renewable energy investment and financing was analyzed from the following aspects: investment situation; investment and financing bodies; financing means, project funding sources and financing channels. Secondly, Wind power and photovoltaic power financing modes were deeply discussed in this paper, namely, wind power financing is typically government-oriented financing mode, while photovoltaic power is a manufacturer driving mode. In addition, a comparative analysis was taken between these two different financing modes. Finally, the existing issues of wind power and photovoltaic power investment and financing were analyzed and further countermeasures were put forward.

This research will play a significant role in the sustainable development of renewable energy. However, due to the various restrictions which are not entirely described, some conclusions of this paper have to be further addressed and some issues should be extended in future research. Firstly, at present, it was short of relatively independent resource data system of domestic renewable energy and paper-related information, besides, data were collected from different statistical caliber, causing some difficulties for the analysis of this paper and reducing, to some extent, the consistency and credibility of the argument, and it ultimately affected the accuracy of the analysis and judgment. Additionally, the lack of partial data, to some extent, hindered the deep development of this paper. Secondly, this paper merely analyzed wind power and photovoltaic power, of which the development is the relatively mature. However, the development of China's renewable energy while biomass power generation and nuclear power investment and financing issues were not analyzed. In the future study, scholars can deeply analyze other resources of renewable energy, including a detailed analysis of the similarities and differences of different energy resources investment and financing modes. Thirdly, at present, China has not yet a whole business model of renewable energy industry chain financing, thus, it is difficult to quantitatively analyze and scientifically evaluate financing efficiency and cost. Therefore, the focus of next step research is to build the whole business model of renewable energy industry chain financing.

Renewable energy will achieve rapid development for the years to come, and the proportion of renewable energy for the worldwide use of energy will increase rapidly. Thus, the shift of exploitation and utilization gradually from fossil energy to renewable energy will become the main trend of world's energy development. This research is of great implication to the improvement of renewable energy industrial policies and the management system, and this improvement will ultimately enhance the actual position of renewable energy in China's energy strategy and thus ensure China's energy security and environment quality.

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## References

[1] Renewable Energy Law. China State Council, Beijing; 2006.
[2] Patlitzianas Konstantinos D, Christos Kolybiris. Effective financing for provision of renewable electricity and water supply on islands. Energy Sustain Dev 2012;16:120–4.
[3] Ming Zeng, Song Xue, Mingjuan Ma, Xiaoli Zhu. New energy bases and sustainable development in China: a review. Renew Sustain Energy Rev 2013;20:169–85.
[4] Mei Wang, Xiaoli Zhao. Review and analysis of Economic Policies on Wind power Development in China. Energy China 2011;10:4–10.
[5] Ming Zeng, Ximei Liu, Na Li, Song Xue. Overall review of renewable energy tariff policy in China: evolution, implementation, problems and countermeasures. Renew Sustain Energy Rev 2013;25:260–71.
[6] Zeng Ming, Li Chen, Zhou Lisha. Progress and prospective on the police system of renewable energy in China. Renew Sustain Energy Rev 2013;20:36–44.
[7] Wu Q. The financing pattern discussion of China wind power generation company. Environ Sci Manage 2008;1:9–17.
[8] Zeng Ming, Zhang Kun, Liu Daoxin. Overall review of pumped-hydro energy storage in China: status quo, operation mechanism and policy barriers. Renew Sustain Energy Rev 2013;17(1):35–43.
[9] Ching HuiLiao, Hung Ou Hsin, Lien Lo Shang, Te Chiueh Pei, Hwa Yu Yue. A challenging approach for renewable energy market development. Renew Sustain Energy Rev 2011;15:787–93.
[10] Tang Amy, Chiara Nicola, Taylor John E. Financing renewable energy infrastructure: formulation, pricing and impact of a carbon revenue bond. Energy Policy 2012;45:691–703.
[11] Liming Huang. Financing rural renewable energy: a comparison between China and India. Renew Sustain Energy Rev 2009;13:1096–103.
[12] Ming Zeng, Kun Zhang, Jun Dong. Overall review of China's wind power industry: status quo, existing problems and perspective for future development. Renew Sustain Energy Rev 2013;24:379–86.
[13] Kaifeng Li, Hongyuan Zhu, Guiyu Chenyan Zhu. Analysis of relationship between China's energy investment and financing and the development of energy industry. Energy Procedia 2012;14:655–61.
[14] Bhattacharyya Subhes C. Financing energy access and off-grid electrification: a review of status, options and challenges. Renew Sustain Energy Rev 2013;20:462–72.
[15] Wüstenhagen Rolf, Menichetti Emanuela. Strategic choices for renewable energy investment: conceptual framework and opportunities for further research. Energy Policy 2012;40:1–10.
[16] Masini Andrea, Menichetti Emanuela. The impact of behavioural factors in the renewable energy investment decision making process: conceptual framework and empirical findings. Energy Policy 2012;40:28–38.
[17] Thiam Djiby Racine. An energy pricing scheme for the diffusion of decentralized renewable technology investment in developing countries. Energy Policy 2011;39:4284–97.
[18] Muñoz José Ignacio, Sánchez de la Nieta Agustín A, Contreras Javier, Bernal-Agustín José L. Optimal investment portfolio in renewable energy: the Spanish case. Energy Policy 2009;37:5273–84.
[19] Masini Andrea, Menichetti Emanuela. Investment decisions in the renewable energy sector: an analysis of non-financial drivers. Technol Forecast Soc Change 2013;80:510–24.
[20] Patlitzianas Konstantinos D, Christos Kolybiris. Sustainable energy investments in Hellenic urban areas: examining modern financial mechanisms. Renew Sustain Energy Rev 2011;15:5186–93.
[21] Nishihara Michi, Shibata Takashi. The effects of external financing costs on investment timing and sizing decisions. J Bank Finance 2013;37:1160–75.

[22] Boomsma Trine Krogh, Meade Nigel, Fleten Stein-Erik. Renewable energy investments under different support schemes: a real options approach. Eur J Oper Res 2012;220:225–37.
[23] Zavodov Kirill. Renewable energy investment and the clean development mechanism. Energy Policy 2012;40:81–9.
[24] Delina Laurence L. Clean energy financing at Asian Development Bank. Energy Sustain Dev 2011;15:195–9.
[25] Barradale Merrill Jones. Impact of public policy uncertainty on renewable energy investment: wind power and the production tax credit. Energy Policy 2010;38:7698–709.
[26] Liang Wang. China's wind power project financing risk issues. Orient Enterp Culture 2010;18:105–6.
[27] Temporary management method of price subsidy for Golden Sun demonstration projects. China National Ministry of Finance, Ministry of Science and Technology, Energy Administration, Beijing; 2009.
[28] The medium and long-term program of renewable energy development. China National Development and Reform Commission, Beijing; 2007.
[29] Wang Qiang. Effective policies for renewable energy—the example of China's wind power—lessons for China's photovoltaic power. Renew Sustain Energy Rev 2010;14:12–702.
[30] China wind power outlook 2011. Chinese Environmental Industry Press; 2011.
[31] Meng Y. Wind power industry: a study on the public policy in the perspective of industrial evolution. Sci Technol Inf 2010;3:190–1.
[32] Dongming Ren, Ye Tao, Yongqiang Zhao, Runqing Hu, Shiping Qin. Analysis on the problems of the 10 MW PV power concession demonstration project. Sino-Glob Energy 2011;16:5–31.
[33] Kumbaroğlu Gürkan, Madlener Reinhard, Demirel Mustafa. A real options evaluation model for the diffusion prospects of new renewable power generation technologies. Energy Econ 2008;30:1882–908.
[34] Martínez-Ceseña EA, Mutale J. Application of an advanced real options approach for renewable energy generation projects planning. Renew Sustain Energy Rev 2010;15:2087–94.
[35] Zhao Zhen-yu, Yan Hong. Assessment of the biomass power generation industry in China. Renew Energy 2012;37:53–60.
[36] Masini Andrea, Menichetti Emanuela. Investment decisions in the renewable energy sector: an analysis of non-financial drivers. Technol Forecast Soc Change 2013;80:510–24.
[37] Fleten S-E, Maribu KM, Wangensteen I. Optima l investment strategies in decentralized renewable power generation under uncertainty. Energy 2007;32:803–15.
[38] Lee Shun-Chung, Shih Li-Hsing. Renewable energy policy evaluation using real option model—the case of Taiwan. Energy Econ 2010;32:67–78.
[39] Laurikka H, Koljonen T. Emissions trading and investment decisions in the power sector—a case study for Finland. Energy Policy 2006;34:1063–74.